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## **Renewable Generation and Storage Project Industry and Laboratory Recommendations**

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Prepared by  
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## **Renewable Generation and Storage Project Industry and Laboratory Recommendations**

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### **Abstract**

The United States Department of Energy Office of Utility Technologies is planning a series of related projects that will seek to improve the integration of renewable energy generation with energy storage in modular systems. The Energy Storage Systems Program and the Photovoltaics Program at Sandia National Laboratories conducted meetings to solicit industry guidance and to create a set of recommendations for the proposed projects. Five possible projects were identified and a “three-pronged” approach was recommended. The recommended approach includes preparing a storage technology handbook, analyzing data from currently fielded systems, and defining future user needs and application requirements.

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These participants include the members of the panel at the Photovoltaic Industry Meeting—Tim Ball (Applied Power Corporation), Wayne Taylor (Department of Defense), Herb Hayden (Arizona Public Service), Mike Stern (Utility Power Group), and Jim Drizos (Trojan Battery Corporation); all of the attendees of the Photovoltaic Industry Meeting and the Energy Storage Association Meeting; respondents to the survey distributed at the Energy Storage Association meeting; Jim Rannels, Acting Director of the Department of Energy Office of Photovoltaic and Wind Technologies for his attendance at and participation in the Photovoltaic Industry Meeting; Philip Overholt, Photovoltaic Program Manager, Department of Energy for his attendance at and participation in the Energy Storage Association Meeting; Amber Gray-Fenner for assistance in the preparation of this report; and the staff of the Energy Storage Systems Program and the Photovoltaics Program at Sandia National Laboratories for their participation in this project.

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## Executive Summary

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The United States Department of Energy (DOE) is planning a series of related projects (collectively called the RGS Project or simply “the project”) that seeks to better integrate renewable energy generation and energy storage in modular, turnkey renewable generation and storage (RGS) systems. To determine if a need for such an effort exists and industry’s level of interest in such projects, the Energy Storage Systems Program (ESSP) and the Photovoltaics Program at Sandia National Laboratories (SNL) conducted two meetings to solicit industry feedback. In addition, a third meeting was held with key personnel in SNL’s Energy Storage Systems Department and Photovoltaic Systems Application Department to create a set of recommendations for the focus and scope of the proposed projects.

The first meeting focused on soliciting feedback from the photovoltaic industry. Data was obtained by having a panel of photovoltaic and energy storage users relate their experience and recommendations and by a facilitated round-table discussion. General conclusions from this meeting indicated that batteries were often the weak link in integrated systems that have been fielded to date with respect to both performance and cost.

Suggestions included (1) funding research in areas considered especially weak, including advanced storage technologies, improvements in data acquisition for system monitoring, and system controllers and (2) providing system integrators and other users of energy storage with detailed information about specific types of energy storage devices so that they may choose the best storage device for their designs.

If the project were to include designing and prototyping a complete RGS system, the recommendations included the following:

- Build both a large and a small system.
- Build systems that focus on integrating modular components.
- Use a contest format to choose who will be funded by the project.
- Require the system that is designed to be meet well-defined user needs and application requirements.
- Do not interfere with existing industry initiatives or create competition for already existing products.

Key issues were identified and showed that while there was not a consensus among industry on the form the proposed project should take, there was significant interest in the project.

The second meeting was held to obtain feedback from the energy storage industry. Data was gathered at a round-table discussion and through a survey that was to be returned to the ESSP. General conclusions from this meeting were (1) that the proposed project should meet well-defined user needs and application requirements, (2) that the energy storage industry would prefer an open solicitation to the contest format proposed at the photovoltaic industry meeting, and (3) that there was little support for funding the development of “turnkey” systems.

Specific suggestions included the following:

- Having an organization such as the California Energy Commission, Electric Power Research Institute, Solar Energy Industries Association, or Energy Storage Association

## Executive Summary (continued)

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(CEC, EPRI, SEIA, and ESA respectively) review the request for proposal (RFP) before it is sent out for bids.

- Co-funding (with industry) test projects at the user's site.
- Funding projects, such as testing, which create results that can be widely used by all stakeholders, but that suppliers can't afford.

Once again there was not a consensus from the energy storage industry as to the scope and focus of the project, but there was interest in participating in the project.

At the third meeting, staff members from the Energy Storage Systems and the Photovoltaic Systems Application Departments met to consider the industry feedback and create recommendations for the scope of the proposed project. They recommended the following five ideas as potential projects:

- Prepare a storage technology handbook for renewables that summarizes available information in a way that is usable for system integrators, component manufacturers, and system maintenance personnel.
- Analyze (and/or gather) data from currently fielded systems and/or purchase a limited number of existing integrated packages and perform field tests.
- Issue an RFP for the first phase of a multi-phase project. The goal of the first phase would be to identify future user needs and application requirements for improved integration of renewables with storage systems.
- Perform research into software development for advanced system control that could be implemented by industry.
- Perform laboratory battery testing (specifically gel batteries).

Both the software development project and the battery testing project were viewed as beyond the scope of the initial RGS Project efforts. The meeting participants recommended a "three-pronged" approach that includes preparing a storage technology handbook, analyzing data from currently fielded systems, and defining future user needs and application requirements. These three tasks would be conducted in parallel. Additional research into software development and in-house battery testing could eventually be added to the Project, as necessary to supplement the initial efforts. All participants agreed that a significant amount of collaboration between battery and photovoltaic (PV) manufacturers, and system integrators would be necessary for a successful project.

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## Introduction

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The Office of Utility Technologies at the United States Department of Energy (DOE) is planning a series of related research and development (R&D) projects that would focus on integrating renewable energy technologies, such as photovoltaics (PV), with energy storage, such as batteries, flywheels, or supercapacitors, in modular, turnkey systems. This activity has been designated as the Renewable Generation and Storage (RGS) Project.

To determine if a need for such a project exists, and what direction the project should take, the DOE-directed Energy Storage Systems Program (ESSP) and the Photovoltaics Program at Sandia National Laboratories (SNL), hosted two meetings with industry representatives. The first meeting was held in association with the 26<sup>th</sup> IEEE PV Specialists Conference and the participants were mainly representatives of the PV industry. The second meeting was held in conjunction with the biannual meeting of the Energy Storage Association (ESA) and included mainly representatives from the battery and energy storage industries. These meetings were held to solicit industry feedback on the scope and direction the proposed project should take.

A third meeting was held between the SNL representatives to review and discuss the industry feedback and to make recommendations for the project. This report summarizes the input received during the first two meetings and the recommendations of the third meeting.

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## **Energy Storage Systems Program Overview**

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### ***Background***

The ESSP's vision is that "Energy storage will be highly valuable in enabling the 21st century utility, in a competitive environment, to efficiently provide low-cost, reliable, environmentally-benign service to a broad spectrum of electricity users."

Since its origins in the 1970's the ESSP has evolved with the changing needs of the nation. It began with an emphasis on developing diverse components, but in the 1980s the emphasis switched specifically to battery storage subsystems. In the 1990s integration with the utility grid and demonstrations of turnkey systems were the Program's focus. The Program is currently being driven by the need for reliability (ensuring quality power and reliability for end-users), renewables (enabling the increased utilization of wind and PV power), and productivity (enhancing productivity by increasing efficiency and cost-effectiveness). Now the emphasis is focusing on working with users of energy storage to develop integrated storage systems.<sup>1,2</sup> An overview of the background, mission, and structure of the ESSP is provided in Appendix A.

### ***Stakeholder Input***

This emphasis on the users of storage systems resulted in a series of "stakeholder" meetings. Members of the ESSP met with representatives from investor-owned utilities, electric cooperatives, manufacturers, industry associations, and independent power producers to discuss their storage and integration needs and the role that they see storage playing in the future of the industry.<sup>3</sup>

The following common opinions were expressed during the more than 20 meetings held in 1996:

- Concern about the future in a competitive arena,
- Perception of power quality as the largest near term market,
- Interest in low cost options,
- Interest in storage-based products and services (electricity is becoming a commodity).

### ***Renewables Initiatives***

The ESSP is currently pursuing the following initiatives related to integrating energy storage with renewables:

- Study to identify high-value applications and quantify the benefits of storage with renewables,
- White paper on the status of storage with renewables for on and off-grid applications,
- Testing advanced hybrid control systems with PV and battery systems at Arizona Public Service (APS),
- Providing technical expertise to support DOE renewable programs,
- Meetings (such as those described in this report) to gather industry feedback and guidance.

It is believed that these initiatives will help establish a framework for the proposed RGS Project.

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## Photovoltaic Industry Meeting

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The PV industry meeting on the proposed RGS project was held in conjunction with the 26<sup>th</sup> IEEE Photovoltaics Specialists Conference at the Anaheim Marriott on Tuesday, September 30, 1997 from 12:30 - 4:30pm. The meeting was jointly hosted by Chris Cameron of SNL's Photovoltaic Systems Application Department and Paul Butler of SNL's Energy Storage Systems Department. Attending were approximately 25 participants representing industries including system integration, PV and electrical component manufacturing, the battery industry, a utility company and the Department of Defense (DOD) (contributing from the perspective of end-users of the technology), and several representatives from DOE-sponsored programs at SNL and the National Renewable Energy Laboratory (NREL). See Appendix B for a complete list of the meeting participants.

The meeting was structured as follows. An overview of the ESSP and its relationship with renewable energy technologies was provided (see Appendix A). A panel of industry representatives was invited to discuss their needs for integrating renewables, specifically PV, with energy storage. A battery industry representative was given a chance to address the needs described in the panel discussion and to discuss the battery industry's needs from its perspective. A member of the ESSP presented a proposed outline for the RGS Project. Finally, a facilitated round-table discussion was held to discuss the issues presented during the first portion of the meeting. Appendix C contains the agenda for the meeting.

This section summarizes the panel discussion at the PV industry meeting. It also includes the format and content of the round-table discussion and summarizes the key factors and issues left unresolved at the end of the meeting.

### ***Panel—Renewables Industry Needs for Storage***

**Panel Participants:** Clay Aldrich, Siemens Solar (Chair)  
Tim Ball, Applied Power Corporation  
Wayne Taylor, Department of Defense, US Navy China Lake Facility  
Herb Hayden, Arizona Public Service  
Mike Stern, Utility Power Group

#### ***Tim Ball, Applied Power Corporation***

Applied Power Corporation (APC) is a systems integrator that has been using batteries in its systems for 16 years. In the past, their primary focus has been off-grid. They have just recently expanded into grid-connected systems.

APC's main markets are telecommunications, remote markets and other isolated areas, and DOD applications. Wayne Taylor of this panel is one of their customers. According to Tim Ball, "What Wayne wants, APC should be providing."

The majority of the systems provided by APC are "small, out-the-door systems" that use lead-acid or valve-regulated lead-acid (VRLA) batteries. The larger telecommunications systems use VRLA batteries. APC's largest system is a 115- to 140-kW PV hybrid system.

## **Photovoltaic Industry Meeting**

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Batteries are the weak link in these systems. Batteries are also the only high-maintenance components in these systems. For systems used in remote locations, maintenance can be a big issue because of the cost involved in getting people to the site to do the maintenance. Further, the life span of the system (and all of the associated components except batteries) is much greater than that of the battery. In seven years, replacing batteries is a big expense/limitation for the customer. Tim would like battery life spans to be increased. A twenty-year life span would be desirable because then the batteries would last as long as the rest of the system.

Additionally, the cost of PV modules and inverters is coming down. The cost of batteries fluctuates according to the current price of lead. If the costs of batteries cannot be decreased, batteries will soon become the most expensive part of the system. If batteries do become the most expensive part of the system, it reflects badly on the batteries and creates a negative impression of the overall system because the state-of-the-art components (which are generally thought to be expensive) are actually cheaper than “old technology” components (that is, the batteries). Finally, the safety issues involved with lead-acid batteries are well documented. Addressing these safety concerns also adds cost to APC’s systems.

According to APC, improvements in the way systems are packaged can overcome many of the technology limitations of the batteries used in the systems. If better storage is provided, APC feels that it can address the integration issues.

### ***Wayne Taylor, Department of Defense, US Navy China Lake Facility***

Wayne Taylor defined the following two major needs for the energy storage systems used in his programs: safety and maintainability. The types of systems used, the negative factors associated with using the systems, and the priorities for addressing the negative factors were presented.

#### **Safety**

Wayne’s safety issues involved energy storage for small remote PV systems (1-20 kWh of storage) and for PV/diesel hybrids (1-5 MWh of storage; the amount of PV used depends largely on cost).

For DOD applications, it is difficult to comply with National Electrical Code (NEC) standards at the voltages currently being used. According to the NEC, steel cases and other metal parts must be grounded. At 600 V the required grounding is unacceptable because of ground fault paths. Fires have resulted when leaking electrolyte caused a path to ground. Conductive paths are created on almost any lead-acid battery. Plastic cases and nonmetal earthquake bracing would help to alleviate this problem. An additional safety issue is that materials used to make batteries are hazardous according to material safety data sheets (MSDS) for the products.

The priorities for creating safer batteries should be as follows:

- Eliminate possibility of ground fault current paths.
- Eliminate possibility of explosions from gas emissions.
- Fund research on alternative storage technologies.

### **Maintainability**

The maintainability issues were related to any PV-powered system. First, replacement electrolyte for leaking batteries is costly to ship. Second batteries require “excessive” maintenance. For the PV systems used by DOD, 20% of the initial system cost is for the batteries, but 90% of the system maintenance cost is for batteries. For example, the battery used for the newest PV/diesel hybrid required eight man-days per month of battery room maintenance to keep the manufacturer’s warranty valid.

The short life span of batteries is also a concern. Seven years is the maximum on a “reasonably rated” battery system. Also, batteries are too temperature dependent. Using batteries for long periods at high temperatures reduces their life span, and using them at low temperatures reduces their capacity.

Finally, batteries are difficult to move because they are heavy. Also, there is not any good data available on standard charge/discharge cycles for PV use.

The priorities for creating more easily maintainable batteries should be as follows:

- Reduce required maintenance by 95% (in other words, substantially).
- Fund research into alternative storage technologies.

The DOD wants 1) the ability to work on batteries with no face shield, safety glasses, apron gloves, etc. (minimize the hazards associated with batteries and battery maintenance) and 2) an energy storage system that lasts as long as the PV modules charging it.

### **Herb Hayden, Arizona Public Service**

APS is responsible for the entire life cycle of integrated PV/energy storage systems. APS feels that the public is being “oversold” on PV as the “ideal” solution to energy production (reducing emissions from fossil fuels, etc.). Additionally, while energy storage systems can help with short term peaks (power quality issues) they are not useful on a large scale for long-term (> 2 hours) peak shaving because they are not economically attractive compared to other options.

Herb reiterated the common concerns of lower cost, longer life, transportation cost, and the environmental concerns associated with using batteries for energy storage. Batteries are considered a liability because of the risk of misuse, especially in high-temperature applications. However, in his opinion, the battery industry is the only industry “doing anything” in the energy storage market. “Where are the other industries?” To become a commercially viable storage technology, there must be multiple suppliers and a volume market.

According to Herb, the government should be focusing its R&D money in two areas—lead-acid battery information and alternative storage technologies, specifically flywheels.

## Photovoltaic Industry Meeting

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### Lead-Acid Battery Information

DOE should produce and provide information so that a customer can effectively evaluate different energy storage options. That is “for our operating regime, here are our options.” Right now, battery suppliers provide different types of information and in different ways. Much of the material provided by manufacturers is sales and marketing information and is not objectively presented. Herb recommends screening different battery products every year and finding a way to say “to get ‘x’ performance out of a battery, do this.”

In addition to performance information, people who use energy storage systems are interested in the cost per delivered kWh. Performance curve-type information could help to provide answers to such questions as, “What is the maximum kWh produced per pound of lead for a particular battery?” “Electricity is a commodity business,” the more costs can be quantified, the better.

### Alternative Storage Technologies

“What happened to flywheels?” It is difficult to compete with fossil fuel in terms of cost, but for a storage technology, can't flywheels be competitive with batteries? Or isn't there another technology that could compete with batteries?

After funding the collection and presentation of objective lead-acid battery information, flywheel development should be funded next. In general, the cost/benefit ratio of other storage technologies should be quantified.

### Mike Stern, Utility Power Group

The Utility Power Group (UPG) is an integrator of grid-connected renewable energy systems. UPG sees energy storage systems comprising one or one thousand batteries as a logistical rather than a technical problem. Like everyone else, they would like batteries that are safer, have longer life, and are easier to maintain. He agrees that flywheel technology should be investigated and pursued—“they have great potential.”

They see two types of markets for grid-connected renewable energy with storage systems, big (similar to the one in Chino, California) and smaller packages (similar to those described by Tim Ball earlier in the panel). Batteries are a key issue in the systems UPG designs. What they want to know is “How does battery energy storage add value to (already expensive) PV for grid-connected applications?”

### Big Systems

These systems are large enough to justify full-time maintenance personnel. They are used for power quality and peak shaving applications. The cost involved in these energy storage systems is a big concern. Also, the electrolyte-induced ground faults described by Wayne occur with plastic as well as steel-cased batteries. However, he does not feel that the batteries are as hazardous as described by Wayne and feels that the people who are knowledgeable and experienced in battery maintenance do not want to wear protective gear. As far as battery life-span is concerned, UPG is interested in number of cycles (rather than years).

### **Smaller Package Systems**

These systems are designed for people who want grid-connected (as opposed to stand-alone) PV systems to back up their grid power. In other words “when the power goes out, PV takes over.” The value of these systems is not so much economic, but the perception of value to small customers. The grid-connected, small residential market is also magnitudes larger than off-grid applications of the same size.

Batteries will allow system integrators to realize the true value of PV for the grid-connected, small residential market. From an integrator’s perspective steel trays (or cases) are good. They are durable and sturdy when moving the batteries (plastic trays bend) and their conductivity becomes a problem only at elevated voltages (as described by Wayne). Maintenance will be a big issue because the average homeowner does not want to do a lot of maintenance on the system. It needs to be “user-friendly.” Work also needs to be done on the integration side of the system— inverter failures are common. The brains of the system are in the power electronics which serve as a “robotic baby-sitter.” Consequently, the power electronics need to work as well as the storage technology.

Because this market requires short term storage, supercapacitors may be a preferable alternative to batteries because they have a longer cycle life. Data on lead per kWh, cycling, and calendar life would also be helpful in determining which batteries are best suited for this market.

### **Summary of Panel Recommendations**

For battery technology, improvements must be made in the following areas:

- life span
- maintainability
- safety
- cost

The first three items in the above list also directly or indirectly affect cost (the fourth item). Objective and comparable information on charge/discharge cycles and more useful cost information (for example costs quantified by kWh) are also necessary to make good decisions about which battery is best for a particular system. There is a desire for alternative storage technologies to be developed. It was implied that such alternatives would be widely used if they were commercially available and competitive with batteries.

### ***New Storage Products for Renewable Systems—Jim Drizos, Trojan Battery***

None of the concerns described by the panel are new and, consequently, are well understood by the battery industry. The battery industry feels that users do not adequately understand the technology issues associated with choosing and maintaining batteries and that users are basically “looking for a Lexus at the price of a KIA.”

### **Applications Design**

Lead-acid batteries are designed for a wide variety of uses. The battery industry does not consider energy storage integrated with PV as a “different type” of application. PV is essentially the same as an uninterruptible power supply (UPS) or a telecommunications system. One large difference for stand-alone telecommunications systems is that they have no commercial feeder (the utility grid). Therefore, providing sufficient current to charge the batteries properly becomes cost prohibitive. Consequently, users don't charge the batteries properly, which negatively affects their life span and performance.

According to Jim, the big difference between PV applications and telecommunications or UPS applications is that in the latter applications batteries are online to generate revenue. When batteries begin to generate revenue for PV, they will become necessary, rather than the weak link. The question, then, is “What is it going to take to make batteries generate revenue in PV applications, or what needs to be done to make this happen?”

Technologies other than lead-acid batteries will be more expensive no matter what is done to make these technologies more commercially viable. Additionally, there is generally a 20 year gap between the development of a technology and it becoming commercially viable. In the meantime, lead-acid batteries are the most cost-effective option for energy storage.

As far as the hazardous nature of lead-acid batteries, lead is the most recycled metal in the country, surpassing both aluminum and steel. This is very important when considering the widespread use of lead-acid batteries.

Users need to understand the reality of advances in lead-acid battery technology; the improvements are not visible. Battery technology is 100 years old. To the battery industry, it appears that all of the big advances in lead-acid technology have already been made. Incremental advances continue to be made, but they are not as obvious as large advances.

### **Perceptions and Issues**

Users of both telecommunications systems and UPSs have had the same concerns as mentioned by the panel. However, manufacturers have become more responsive to their customers and the battery users have been more responsible about properly maintaining the batteries they purchase. Many of the safety concerns mentioned by the panel occurred because of regulations, and because of safety inspectors who understand the regulations (but not the technology) mandating requirements that reduce instead of increase safety. For example regulations and inspectors require manifolds in circumstances where the installation of manifolds may cause gas emissions to build up, potentially resulting in an explosion. This situation was mentioned by Wayne earlier in the panel discussion.

Additionally, the NEC may need to be revised to accommodate the kinds of applications being discussed by the panel. The NEC is written and reviewed largely by alternating current (AC) experts who, in this case, are writing codes for direct current (DC) applications. What is of great concern in an AC application may not be so in a similar voltage DC application.

Finally, “price chasing” by end users can cause problems for the users. Users feel that the battery industry doesn't support them and is unresponsive to their needs, but the battery industry is not making sufficient profit margins to fund research into large-scale technological improvements. An increase in profit margins could also fund more testing of standard battery types under a variety of different circumstances and allow for the distribution of the data gained from such testing.

### **The Hope for Tomorrow**

Trojan is currently developing a bipolar battery with 30-40% more capacity for the same weight. They hope to get more use out of the active material, but, in his opinion, this increase cannot be considered substantial when considering MW of storage and lead-acid batteries.

### ***Proposed Project Outline—Garth Corey, SNL Energy Storage Systems Department***

The proposed RGS project could result in the design, fabrication, and testing of a pre-prototype integrated system. The emphasis may be placed on developing an “integrated, modular, turn key system.” These integrated systems are expected to provide advantages over “mix and match” systems.

The ESSP expects to cost share in the development of the system. The ESSP will also attempt to partner with the renewables and electronics industries in developing the system if an integrated-system approach is taken.

### **Advantages of Integrated Systems Over “Mix and Match” Systems**

Integrated, modular, turn key systems can offer a potential cost as low as \$500 to \$750 per kW with volume production. Integrated systems improve performance and increase reliability because the components are designed to optimize performance for the specific system. The components are also designed to optimize the size of the system. Additionally, these systems can be designed to incorporate many “standard” parts and will provide “seamless” transfer between the PV and storage portions of the system.

### ***Round-table Discussion—Nancy Clark, SNL Energy Storage Systems Department (Facilitator)***

#### **Structure and Focus of the Round-table Discussion**

A round-table discussion was used to collect industry feedback and ideas. The discussion was specifically structured so that everyone would have a chance to speak and be heard. The government and national laboratory representatives present during the meeting were asked to listen to all of the industry feedback before being invited to give their opinions and comments.

## Photovoltaic Industry Meeting

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As described in the previous section, the ESSP has proposed a project that will integrate renewables with storage using a modular, factory-integrated, turn key system. This facilitated portion of the meeting was designed to solicit industry opinions on the proposed project and also to describe their ideas for how the project could be focused based on the needs described in the panel.

The facilitator identified the following three questions as the most useful for defining the structure and scope of the proposed project:

1. What would be the key factors in a Statement of Work (SOW) for this project?
2. How should the winning bids be chosen? (selection criteria)?
3. How should this project be justified as value added?

### **Industry's Response to Question 1—"What would be the key factors in an SOW for this project?"**

Many participants felt that a big hardware project was unnecessary and suggested smaller, incremental projects. They asked that the project emphasize modularity; using systems that are easily expandable if more power is needed, such as 1kW to 50kW modules that could be connected in series or parallel.

Many also agreed that the development should meet user needs and application requirements. Included in this assertion was that bidders should specifically define user needs and application requirements in their proposals and define the potential customer base. Also, the SOW should require that the bids be easily comparable. In other words it should provide concrete specifications on how the bids should be structured and what information should be provided to the reviewers. Bidders who do not follow the specifications should not be considered.

According to the panel and the participants in the discussion, the focus should be on *advanced* storage technologies such as flywheels and superconducting magnetic energy storage (SMES). Batteries are perceived as the most cost-effective storage technology, but they are becoming the most expensive part of the system because of required maintenance and replacement costs. By bringing advanced storage technologies to a more marketable state, the systems could be improved. Additionally, the industry representatives felt that improvements in battery technology are generally incremental—small advances are most likely. Focusing on newer technologies could realize large improvements in usability and cost. Also, the opinion was expressed that battery improvements should be funded by the manufacturers, not by the government because they are already a commercially viable storage technology. At least one participant disagreed and stated that the focus should be on improving existing storage technology and that research should focus on integration.

Support was given for funding a project (or a portion of the proposed project) that would regularly publish current and objective information on available battery technology. The information should be detailed and presented in a single format. It should include results for life cycle testing, cost per kWh, kWh per pound of lead, etc. Manufacturers' data is generally sales-oriented and different manufacturers supply different data depending on their marketing strategy. The suggested project would be a DOE-funded educational project for battery users. DOE funding could also be used for testing as well as for publishing the results.

One participant suggested that the SOW should take the form of a contest with a fixed objective, for example the development of a 2- to 4-kW home PV system. The SOW would provide a small fixed-dollar investment to all qualified bidders using concrete criteria to determine who receives the initial money. Then, the bidder who develops the best system for the initial investment money would get full funding to further develop and test the product. Many of the discussion participants liked this idea, however there was some lively discussion as to whether there is really a market for small home-PV systems. It was also mentioned that a small market already exists and that the government may not want to “compete in this market.”

It was suggested that a formal educational component be included in whatever project is created. The educational initiative would be responsible for disseminating the information obtained in the project to people who can use it. To an extent, the educational component also addresses Question 3 (how can this project be promoted as “value-added?”). It was felt that taxpayers who are educated about the project can more accurately determine if it has value to them.

Finally it was suggested that the project focus on providing low-cost data acquisition and control subsystems that can be interfaced to communication networks for remote dispatch, monitoring, and reporting. The data acquisition and control subsystem is a fundamental part of the entire system, without it, users cannot tell what the state-of-charge of the battery is and do not have access to other important system information. According to one participant, not enough attention is being paid to creating accurate, easy-to-use data acquisition and control components for these systems.

Some additional comments made during this part of the discussion included:

- Where batteries are concerned reliability and cost are the main issues.
- The project should address general applicability rather than a specific industry.

### **Government and National Laboratory Representatives’ Responses to Question 1—**

Most of the government and national laboratory representatives agreed that some sort of education initiative would be a good idea. They stated that the national laboratories should be the focal point for any educational effort. The national laboratories should also do some testing to support the educational effort and provide objective performance/cost data. It was suggested that educational information related to product warranties would be a good idea. Someone asked the question “How do we educate people if we don’t actually spec and prototype a system?”

In the past, government research has supported work on PV module reliability and future research should support systems development in the areas of reliability, performance, and cost. The question of how to get funds where they need to go on an integrated-system proposal was raised. Additionally, some felt that the government should stay away from backing specific products. At least one person stated that government should not be totally focused on the market. Others thought that focusing the project on developing and testing a specific product was a good idea. If development and testing of a specific product is pursued, the government should “be discriminating on hardware improvements.” It was also suggested that the project help supplement industry funding to help create teams.

Jim Rannels, the Acting Director of the DOE Office of Photovoltaic and Wind Technologies, and Chris Cameron discussed ongoing initiatives in relation to the proposed project. It was suggested

## Photovoltaic Industry Meeting

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that the new project either address an entirely different area than the existing DOE PV programs—NREL’s “PV Manufacturing Technology” (PVMat) and the DOE/Golden Field Office’s “Building Opportunities in the US for Photovoltaics” (PVBonus)—or complement the efforts of these programs. Jim Rannels also suggested creating a project that would further the cause of the Federal Government’s new “Million Solar Roofs Initiative.” This initiative was created in June 1997 with the goal of manufacturing and installing one million residential and commercial solar systems by the year 2010 and to increase US industry’s share of the global PV market.

### **Discussion of Questions 2 and 3—“How should the winning bids be chosen? (selection criteria)” and “How should this project be justified as value added?”**

Questions 2 and 3 were never addressed directly. However, some answers to these questions were suggested by the answers to Question 1. First, concerning Question 2, it was suggested that the selection criteria be designed so that all bids are structurally similar. Second, most industry representatives agreed that market research data be included to support the claims made in the proposals. Third, the ESSP should make sure that the proposed project doesn’t interfere with existing government or industry initiatives or products. Finally, the idea of using a contest format to ultimately decide who receives the majority of the funding was popular.

Concerning Question 3, it was suggested to address issues of technological competitiveness and then focus on reliability, performance, and cost. Focusing on education was seen as important in improving the understanding of the purpose of the project and its results.

### **Key Factors Wrap-Up**

The facilitator summarized the round-table discussion and distilled the industry recommendations and discussions into the following four key points:

1. More information is needed on energy storage devices, more emphasis should be placed on enhancing the utilization of these devices, and/or research should be directed towards finding a better device.
2. Government should support either an integrated or a modular system, but the decision should meet defined user needs and application requirements.
3. Use the contest format, in one or more levels, to help choose who could receive the bulk of the R&D money.
4. The project should have a component focus, particularly emphasizing system-monitoring and/or control components.

The facilitator then asked meeting participants (both industry and government) to check which of these key factors they agreed with. They could mark more than one.

Question	Number in Agreement
1	6
2	7
3	12
4	10

## ***Key Issues Left Unresolved***

### ***Should the project be market driven?***

For the most part, the industry representatives agreed that RGS Project should be market driven. A valid issue was raised as to whether or not the government should be involved in projects that already have a clearly defined market. Funding research into areas that have clearly defined markets could be perceived as “corporate welfare.” It was suggested that R&D funding be provided for markets that are seen as “potential” or “emerging.” This type of funding would address markets that could be commercially viable in less than 20 years.

### ***Should further R&D in battery technology be funded by DOE?***

Battery manufacturers do not want to fund R&D on large-scale utility batteries because right now this is a small market. The question is, should large-scale utility batteries be considered an “emerging” market for the purposes of this project. Also at issue is whether or not the government should be funding research into this market whether it is emerging or not, since batteries are such an established technology. Who is ultimately responsible for R&D on an existing technology in a new application with new requirements?

### ***How will DOE ensure that the proposed project does not interfere with current industry initiatives?***

According to the meeting participants, industry is already successfully integrating renewables and storage. It is important if DOE decides to fund a project to research modular solutions that it does not encroach on what industry is already doing. Several system integrators were present in the meeting. Some feel that they are doing the “mix and match” method quite well, however, there was some disagreement as to how well this was being done. Some industry representatives disliked the “factory-integrated turnkey” model because they felt that it was not as easily adaptable to customers needs. They considered the “mix and match” method to be extremely flexible.

### ***Should the proposed project be combined with current initiatives of the Federal Government and national laboratories?***

As stated previously, there are several ongoing government initiatives that focus on PV. It was not determined whether this project should be an entirely different initiative, a complementary effort, or possibly combined with one or more of the other programs.

### ***Should systems that integrate renewables and storage be modular and integrated on site or turnkey and integrated at the factory?***

This was the biggest unresolved issue. The project proposed at the beginning of the meeting specified that the focus of the project should be developing and testing a pre-prototype factory-integrated system. However, from the panel and the round-table discussion, it was clear that the majority of the industry representatives preferred a project that focused more on developing standardized components for use in modular systems (supporting the “mix and match” method). Nevertheless, at least one industry representative preferred the factory-integrated approach.

## **Photovoltaic Industry Meeting**

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As previously stated, modular systems offer a great deal of flexibility. Even the industry representative who favored factory-integrated systems admitted that one problem with these systems is that buyers invariably ask for changes to the system specifications, which sometimes lead to problems with system integration. It is, however, fair to ask whether the integrators should be telling customers what to buy or supplying what the customers request.

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## **Energy Storage Industry Meeting**

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The energy storage industry meeting was held in conjunction with the biannual ESA Meeting in Sacramento, California on November 18, 1997. The meeting was hosted by Philip Overholt of DOE and Paul Butler of SNL's Energy Storage Systems Department. Attending were 52 participants representing industries and organizations including battery manufacturers, government and non-profit organizations (for example SEIA), and electric utilities. See Appendix D for a complete list of the meeting participants and Appendix E for the meeting's agenda.

The meeting was a round-table discussion focusing on some of the issues that were left unresolved at the photovoltaics industry meeting. To provide additional information, meeting participants were given a survey to complete and return. A copy of the survey is provided in Appendix F.

### ***Round-table Discussion***

The participants were asked to discuss their agreement or disagreement with the following four points:

- The RGS Project should provide more information on energy storage devices and more emphasis on enhancing the utilization of these devices, and/or find a better device.
- The government should support either an integrated or a modular system, but the decision should meet defined user needs and application requirements.
- The project should use a contest format, in one or more levels, to choose who will receive the bulk of the R&D money.
- The project should have a component focus, particularly emphasizing system-monitoring and control components.

There was significant debate as to whether advanced storage components should be developed and included in the proposed project. Flywheel developers stated that their technology was ready to be integrated and should be part of the project. However, others believed that commercially-available technologies (i.e., batteries) should be the focus of the RGS Project and that proper integration of the storage technology would be the key to the Project's success. Providing information on storage, power electronics, and controls was also recognized as a key to successful implementation of the Project, but there was no consensus on how to efficiently perform this education.

One idea that was debated was the possibility of developing advanced, microprocessor-based controllers that could sense the battery type and condition, and adjust or select the proper charge characteristics and other control parameters to optimize system performance. Batteries could identify themselves to the controller. Then the controller would perform system control based on data describing the battery type that had been programmed into the controller's memory. Or, control regimes could be updated periodically, similar to the way computer software is updated today. Thus the RGS Project could focus on the controller, software development, sensor selection, and battery self-identification technologies.

## **Energy Storage Industry Meeting**

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There was support for the Project to be market driven. However, cost implications may encourage work on advanced components that have the best potential for lower ultimate cost. There was little support for turnkey, integrated system development. Also, little support was given for the contest format proposed at the PV industry meeting.

### ***Survey Responses***

Six of the approximately 50 surveys distributed at the energy storage industry meeting were completed and returned. Some respondents, however, did not answer all of the questions. The responses to each question are summarized below.

#### ***Question 1—What are your recommendations for the structure and implementation of the RGS Project?***

It was recommended that an RFP for the project include a well-defined problem related to integrating storage with renewables “that will be useful to the market.” Then an open solicitation should be requested. The RFP should not limit the solutions to those involving PV and lead-acid batteries. One respondent suggested funding “one to five demonstrations.” However, “no one should try to get in the middle of ESA’s storage community and SEIA to resolve all of the RGS project issues.” It was recommended that DOE facilitate a “face-to-face” meeting between the stakeholder groups and provide staff to assist in a joint effort to define the RGS project.

One specific recommendation was to identify and document the technological impediments to more widespread implementation of integrated technology. If this study indicates that the batteries being used are the primary issue, then undertake a test program and develop a “smart” battery.

Another specific recommendation suggested focusing on technologies with a “two-to-five year time horizon,” including non-electrochemical storage technologies (such as flywheels and SMES). The respondent also stated that cost-sharing should be a requirement for the proposed project.

#### ***Question 2—Should the project be market driven?***

All respondents agreed that the project should be market driven, or at least have a potential market. One respondent cautioned that “in particular it needs to be understood that the end-user, not the system integrator, is the customer,” when considering the market for the project. Additionally, some respondents indicated that the market needed to be identified or defined before the RFP was issued. During the PV industry meeting, representatives indicated that the *proposers* should be responsible for identifying the market. An energy storage industry representative indicated that the market identification/definition should be included as a part of the proposed project, in other words provided by the RFP’s *issuers* rather than the proposers.

#### ***Question 3—Should DOE fund further R&D in batteries and advanced storage technologies now even if this means postponing systems research?***

Most respondents to this question indicated that systems research should be continued—“systems integration is critical.” One considered research related to batteries and advanced

storage technologies as “micromanaging the process.” Another mentioned that R&D on batteries and other storage technologies is already being well funded by programs for electric vehicles. Some felt that systems research into developing methods to better integrate available technologies with each other or to better understand which applications work best with each other (for example, flywheels and motor generators) was especially necessary.

However, one respondent felt that additional battery research was necessary, even if that meant less systems research—“Imagine if there were battery technologies that were a lot closer to ‘ideal’ (less idiosyncratic and limited)...Imagine a cheap integrated circuit device ‘smart’ charger that could control the interface between any source of supply and any battery.”

**Question 4—How will DOE ensure that the proposed project does not interfere with current industry initiatives?**

Most respondents felt that by working closely with industry and with the stakeholder groups, conflict with current industry initiatives could be avoided. It was suggested that organizations such as CEC, EPRI, SEIA, and ESA review the RFP before it is sent out for bids. Additionally, potential conflicts might be avoided by co-funding (with industry) test projects at the user’s site or by “solely funding projects, such as testing, which create results that can be widely used by all stakeholders, but that suppliers can’t afford.” However, one respondent felt that there was no way DOE could avoid interfering with current initiatives if the project “is designed to solve a problem that the military hasn’t already solved and is offered in an open solicitation.” In other words an open solicitation probably will produce bids that compete in some way with existing initiatives.

**Question 5—Should the proposed project be combined with current initiatives of the Federal Government and national laboratories?**

Responses to this question were evenly split among the four who answered it. From the responses, it appeared that a “combination” of programs would not necessarily be the best approach and that a “collaboration” or possibly “coordination” where the projects remain autonomous, but share information would be better received. One respondent suggested that “joint reviews” be used to “verify that the collaboration is taking place.”

**Question 6—Should work focus on factory-integrated, turnkey systems or on modular components that are integrated by the system suppliers?**

Again, responses to this question were mixed. It appeared that many supported component research, but also felt that a “system approach” was necessary to determine which components work best in specific types of systems. One respondent voiced strong support for “factory-integrated turnkey systems that are ‘black boxes’ to users,” but also stated that “module development may be necessary to get a good ‘black box’.” Another respondent stated that the focus should be defined by the problem...in other words, “just have an open solicitation for solutions to a well-defined problem.”

## Energy Storage Industry Meeting

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For Questions 7 through 9, respondents were asked to indicate their level of agreement with the statement on a scale of 1 to 5 (strongly disagree through strongly agree) and provide supporting comments.

### **Question 7—More information on energy storage devices, more emphasis on enhancing the utilization of these devices, and/or find a better device.**

Most respondents agreed or agreed strongly with this statement (three answered “5”, one answered “4”) and one strongly disagreed. The respondent who disagreed felt that EPRI and storage device manufacturers had already published a substantial amount of information. One of the respondents who strongly agreed with providing information stated that *no* effort should be made to “find a better device.”

### **Question 8—Government should support either an integrated or a modular system, but the decision should be market driven.**

Most respondents felt that the decision should be market driven, but one disagreed with the idea of supporting one type of approach or the other and suggested an open solicitation. Additionally, one respondent felt that a market-needs analysis should be done first and that this analysis would show that “integrated systems are desirable.”

### **Question 9—Use a contest format to choose who will receive the bulk of the R&D money. The project should have a component focus, particularly emphasizing system-monitoring components.**

Support for the contest format was minimal. One respondent agreed (“4”) another made no comment (“3”). Two respondents disagreed with the statement ( one answered “no” but did not provide a quantifying number answer, the other answered “1”). Of those who disagreed, one stated that “there should be no big prize and a few demonstrations.” Of those who agreed, one stated that there should be “limits” to the contest format. This respondent, however, disagreed that the contest should have a component focus.

### **Question 10—Another group suggested that system designers and integrators would find useful a handbook or guide that contained detailed specifications for many different types of batteries. Do you feel that such a handbook is necessary/desirable? If so, and if you represent a battery manufacturer, would your company be willing to provide batteries for testing to support such a handbook?**

Of the respondents who answered this question, only one stated that it would be “a waste of time and effort.” The other responses were lukewarm at best—“maybe this is desirable,” “I think such a handbook would be nice...” One respondent suggested “providing a number of case studies/post-mortems of actual field experiments for lessons learned, identifying actual problems that need to be addressed, and education.” Another felt that having battery suppliers/experts participate on a system development team would be more useful. The suggestion was made to include ultracapacitor information if the handbook was prepared.

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## **SNL RGS Recommendations Meeting**

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A meeting was held in Albuquerque, NM on January 5, 1998 to develop a set of options for defining the RGS Project. Attending were Paul Butler, Chris Cameron, Nancy Clark (facilitator), John Stevens, Garth Corey, and Tom Hund of SNL and Amber Gray-Fenner (technical writer/report editor). The meeting was a facilitated round-table discussion to consider the recommendations and feedback described in the previous two sections of this report. The goal was to use industry's recommendations and the available expertise to create potential directions for the proposed RGS Project. The resulting potential projects are presented below, followed by SNL recommendations for the proposed RGS Project.

### ***Potential RGS Projects***

The meeting participants proposed the following five ideas as potential tasks for the RGS Project. Each idea will be discussed below:

- Prepare a storage technology handbook for renewable systems.
- Analyze (and/or gather) data from currently fielded systems and/or purchase a limited number of existing integrated packages and perform field tests.
- Issue an RFP for the first phase of a multi-phase project. The goal of the first phase would be to identify user needs and application requirements for improved integration of renewables with storage systems.
- Perform research into strategies and software development for advanced system control.
- Perform in-house testing on improved storage components.

### ***Prepare a Storage Technology Handbook***

The idea for a handbook was originally suggested at SOLTECH 97 and at the PV industry meeting. The handbook would be a "living document," published on the World Wide Web, with print copies available by request. The target audience for the handbook would be renewables system integrators, component manufacturers, and system maintenance personnel. The purpose of the handbook would be to:

- Define renewable applications and the issues involved with integrating storage technologies with renewables,
- Provide detailed characterization of a variety of available batteries and other storage devices in an unambiguous manner, and
- Function as a guide that can be used by system integrators to assist in system design.

It was agreed that information on all storage technologies should eventually be included in the handbook but, because batteries are the most common near term solution for integrating storage with renewables, the handbook should initially focus on providing information about batteries. For the initial publication, it was recommended that the emphasis be on collecting and publishing battery data currently available. Some of this information exists in manufacturers' marketing material and must be restructured in a way that is useful for comparison. Once the available data has been collected it will be supplemented with test data specific to renewable applications.

Ideally, the handbook would address the most common battery types: flooded lead-acid and VRLA (glass mat and gel). It would address safety issues, specifically the safe use and

## **SNL Recommendations**

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maintenance of batteries (watering, venting, cleaning, etc.) and provide information on which batteries are best/worst suited for particular applications (beginning with the manufacturers' recommendations for appropriate use of the battery). The handbook should also provide information on the load profiles, depth-of-discharge, and proper operating temperatures for the various batteries; the environmental effects on battery efficiency and life; and charging options available for the batteries, including the effect of particular charging regimes and duty cycles on the batteries' efficiency and life.

### **Analyze (and/or Gather) Data from Currently Fielded Systems and/or Purchase a Limited Number of Existing Integrated Packages and Perform Field Tests**

This option would identify where integrated RGS systems exist and where they are located, then go to the site and gather data or obtain data from existing monitoring systems. The results of the data analysis would be used to provide an assessment of systems that have been in the field for a while. The systems would not be tested under similar conditions, but the data obtained would be based on how the systems are actually being used (or abused).

If existing systems are not appropriate for this purpose, another approach would be to purchase a limited number of existing integrated packages and perform systems tests in the field under controlled conditions. This testing would facilitate an “apples to apples” type comparison of different integrated RGS systems. If the systems perform adequately, the results would be published. If not, the results would still be published, but they would include an identification of the problems and shortcomings of the various systems. The results of the tests would also be analyzed to identify possible development ideas for addressing the problems and shortcomings.

### **Issue an RFP for the First Phase of a Multi-phase Project to Identify Future User Needs and Application Requirements for Improved Integration of Renewables with Storage Systems**

The work identified in the RFP would have two goals—First, to define the present and future needs of existing users of RGS systems and second to determine application requirements of RGS systems that would meet these needs.

The RFP will define work that will be considered Phase One of an RGS project that could eventually include issuing an RFP for developing and testing an integrated renewable system, should a need and application be identified. It is thought that by including and funding this “needs analysis” as part of the entire RGS Project, rather than requiring that bidders for future phases of the Project supply (and fund) the needs analysis themselves, a larger number of bidders will be encouraged to compete for the RFP. It will also help those who are reviewing the proposals to determine if a particular bid or system competes with established products (which was a major concern of industry). Finally, it will also help to determine the potential number of users for the products that are found to not compete with existing products. The ability to estimate the number of potential users for the proposed products is essential to ensuring that the system developed by the final RFP be “market driven” as expressed in the earlier meetings.

To adequately define user needs and application requirements, Phase One must consider the maintainability of existing systems, the most common operating environments for the systems, and the load characteristics of the present applications. It would describe what would be considered ideal for “cookie cutter” systems that could be provided to the widest segment

potential users. It is possible that a few different systems may be required depending on the environment and load issues. The work should also identify the competition that already exists for the users and applications being described. Identifying the competition will allow program management to decide if funding additional R&D in these areas would provide an unfair advantage to competitors or interfere with initiatives that are already funded, or products that are being sold by industry. Once the users' needs and applications requirements have been defined, the work should then identify where certain needs are not being adequately addressed and provide recommendations (system design) on how these needs could be filled. The work could also discuss and provide ideas for solutions to what is seen as lacking or the major problems in certain existing applications.

Specific recommendations for Phase One were also discussed. It was suggested that small grants or contracts be awarded for work on Phase One, then additional funding for later phases would be awarded to a small number of teams that had exceptional insights and recommendations. It was also suggested that the RFP for Phase One require bidders to focus on entry into a new application or area, rather than on an area that already has "healthy competition" or is already being funded by another program. For example, small-residential and telecommunications applications are already being funded by the PVMat program. The new project could address village-scale applications. By focusing on village-scale projects, additional funding for the project might be available from the World Bank, which is apparently looking for support from the national laboratories for small, remote systems.

### ***Research Software Development for Advanced System Control***

Another idea was for the project to address the issue of remote system monitoring and control. Currently, individual manufacturers or system integrators provide the software used for monitoring and controlling the systems and it is different for each system. One participant thought that with appropriate research and planning, "one-size-fits-all" software could be developed that could be used by all systems.

Ultimately, the software would be developed to accommodate all possible types of storage technologies, renewable energy sources, and the sensors used for remote monitoring and control of the system. When a system is manufactured or integrated, the appropriate parameters would be entered into the software which would then provide the appropriate level of remote control and monitoring for those components.

### ***Perform In-house Battery Testing***

Testing could be performed to supplement the data available in the handbook or it could be funded as a separate project. Any testing performed would likely have to be cost-shared by participating manufacturers. One participant suggested that data on gel batteries would be especially useful. The question was asked "how do we facilitate testing and communicate the results." This question essentially brought the group back to the idea of a handbook (for communicating the results).

## **SNL Recommendations**

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### ***SNL Recommendations***

The meeting participants recommended a three-pronged approach for the RGS Project. The three areas of emphasis are as follows (in priority order): prepare the handbook, provide an analysis of existing field test data, and issue an RFP for work to define the present and future needs of existing users and application requirements. These three efforts should be started in parallel. Based on the output of these projects, it might be expected that some laboratory testing, field testing, or software development may follow as a result, but not until justified by the “up front” work and not until such testing and/or development could be more accurately specified as meeting an industry need. These recommendations will be presented to DOE for consideration before initiating the RGS Project.

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## Appendix A—ESSP Overview

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Slide 1—



U.S. Department of Energy  
**Overview of the  
Energy Storage Systems  
Program**

DOE RGS Project Meeting  
September 30, 1997

Paul C. Butler *for*  
Christine E. Platt, Ph.D.,  
DOE/ESS Program Manager

Slide 2—



## Vision

Energy storage will be highly valuable in enabling the 21st century utility, in a competitive environment, to efficiently provide low-cost, reliable, environmentally-benign service to a broad spectrum of electricity users.



Slide 3—



## ESS Program History

1970s	Development of <i>diverse</i> components
1980s	Emphasis on <i>battery</i> storage subsystems
1990s	<i>Integration</i> and demonstration of turnkey systems
NOW	<i>User focus</i> in development of integrated storage systems

Slide 4—



## ESS Program Drivers



**RELIABILITY . . .**  
*ensuring quality power and reliability for end-users*



**RENEWABLES . . .**  
*enabling the increased utilization of wind and photovoltaic power*



**PRODUCTIVITY . . .**  
*enhancing productivity by increasing efficiency and cost effectiveness*

Slide 5—



## ESS Program Scope

**Broad Technology Base**

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- v Batteries
- v Power Electronics
- v Component & System Controls
- v SMES
- v Flywheels
- v Ultracapacitors

**Applications Focus**

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- v Power Quality
- v Transportable Systems
- v Telecommunications
- v Renewable Generation
- v Peak Shaving

Slide 6—



## ESS Program Elements

<p><b>Integration</b></p> <ul style="list-style-type: none"> <li>Transportable Systems</li> <li>Renewable Systems</li> <li>Mid-Voltage Systems</li> <li>Field Evaluations</li> </ul>	<p><b>Components</b></p> <ul style="list-style-type: none"> <li>Storage Component Development</li> <li>Power Electronics Research</li> <li>Component Evaluation</li> </ul>
<p><b>Analysis</b></p> <ul style="list-style-type: none"> <li>Benefits and Applications Studies</li> <li>Renewables Studies</li> <li>Technology Studies</li> </ul>	

Slide 7—



## Focus on Integration

Integrated, modular, turnkey systems:

- ∪ Offer potential cost reduction as low as \$500-750 / kW with volume production
- ∪ Improve performance and increase reliability
- ∪ Provide seamless transfer
- ∪ Use components designed to optimize cost, size, and performance
- ∪ Can incorporate standard parts
- ∪ Directly address utility & customer applications

Slide 8—



## PV / Energy Storage Integrated Systems

- ∪ Three ranges represent many applications
  - 1-4 kW (residential)
  - 10-30 kW (telecom)
  - 100-300 kW (village)
- ∪ Standard integrated systems offer potential cost and reliability advantages with well matched components
- ∪ Interest by industry is critical to product development

Slide 9—



## ESS Renewables Initiatives

**The Following Ongoing ESS Renewables Initiatives:**

- ∪ Study to Identify High Value Applications and Qualify the Benefits of Storage With Renewables
- ∪ White Paper on the Status of Storage With Renewables for on and off-grid Applications
- ∪ ESS Sandia Technical Expertise Supporting DOE Renewable Programs
- ∪ Meetings to Gather Industry Feedback and Guidance

**. . . Establish a Framework for the RGS Project**

Slide 10—



## Renewable Generation and Storage (RGS) Project

**RGS will result in the:**

- ∪ Design
- ∪ Fabrication
- ∪ Testing

Of a ***Pre-Prototype, Integrated*** System

**The ESS Program Expects To:**

- ∪ Cost-Share Development
- ∪ Partner with the Renewables and Electronics Industries

Slide 11—



## Stakeholder Input

**Common opinions expressed during more than 20 meetings with industry executives in 1996:**

- ∪ Concern about future in a competitive arena
- ∪ Perception of power quality as largest near-term market
- ∪ Interest in low-cost options
- ∪ Interest in storage-based products and services

Slide 12—



## Stakeholder Meetings

**Executives from the following industries provided valuable input:**

<b>Investor-owned utilities:</b> Potomac Electric Power Northern States Power Indianapolis Power & Light Southern California Edison Central & South West Public Service of New Mexico Southern Company	<b>Electric cooperatives:</b> Allegheny Oglethorpe Salt River Project <b>Manufacturers:</b> AC Battery Exide Electronics GNB Technologies Solarex Superconductivity Inc.	<b>Industry associations:</b> Electricity Consumers Resource Council (ELCON) International Lead Zinc Research Organization National Rural Electric Cooperative Association Solar Energy Industries Association <b>Independent Power producers:</b> AES Trace/Kenetech
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## Appendix B—Photovoltaic Industry Meeting Participants

Name	Organization	Phone/ Fax	E-mail
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## Appendix C—Photovoltaic Industry Meeting Agenda

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**Note:** This appendix was recreated from the original document.

### RENEWABLE GENERATION AND STORAGE MEETING Tuesday, September 30, 1997

#### Agenda

12:00	Introductions (with lunch)	Chris Cameron, SNL
12:15	ESS Program Overview & Renewables Tasks	Paul Butler, SNL
12:45	Panel- Renewables Industry Needs for Storage	Clay Aldrich, Siemens Solar, Chair Tim Ball, APC Sam Edwards, DOD Herb Hayden, APS Mike Stern, UPG
1:45	New Storage Products for Renewable Systems	Jim Drizos, Trojan Battery
2:00	Proposed RGS Project Outline	Garth Corey, SNL
2:15	Round-table discussion to collect industry feedback and ideas	Nancy Clark, SNL, Facilitator
4:15	Wrap-up and summary of key issues	Nancy Clark, SNL, Facilitator
4:30	Adjourn	

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## Appendix D—Energy Storage Industry Meeting Participants

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Name	Organization	Phone/ Fax	E-mail
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## Appendix D—Energy Storage Industry Meeting Participants

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## Appendix D—Energy Storage Industry Meeting Participants

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## Appendix E—Energy Storage Industry Meeting Agenda

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**Note:** This appendix was recreated from the original document.

**Energy Storage Association—Fall Meeting**  
*“The value of energy storage in a restructured utility market.”*

**Tuesday, November 18 (continued)**

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**Technology Forum (continued) 1:45 pm – 3:15 pm**

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Robert Hall, *Holec, Incorporated*  
An Integrated Continuous Power Quality Solution

Mark McIlyar, *Active Power*

Lee McLane, *Precise Power Corporation*  
Mike Stern, *Utility Power Group*  
UPG Renewable/Storage Projects

**Break 3:15 pm – 3:30 pm**

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**ESA Business and Products 3:30 pm – 5:00 pm**

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- Board Summary/Board Elections – Phil Symons, ESA Chairman
- ESA Business Plan '98 – Jon Hurwitch, ESA Executive Director  
Laura Waltemath, ESA Projects Director
- ESA Products – Jon Hurwitch / Brian Highsmith, ESA Coordinator

**ESA Dinner 6:00 pm – 8:00 pm**

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***“Opportunities for Industry in the US Department of Energy /  
Sandia National Laboratories Renewable Storage (RGS) Project”***

**GUEST SPEAKERS**

Mr. Philip Overholt, *Program Staff (Energy Storage and Million Solar Roofs Initiative)*  
*US Department of Energy*  
ESS Overview

Mr. Paul Butler, *Program Manager, Energy Storage Systems*  
*Sandia National Laboratories*  
RGS Feedback

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## Appendix F—Energy Storage Industry Survey

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### Energy Storage Systems Program Renewable Generation and Storage Project Energy Storage Association Questionnaire

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#### ***Background and Instructions***

The Office of Utility Technologies at the United States Department of Energy is considering funding an R&D project that would focus on integrating renewable energy technologies, such as photovoltaics, with energy storage systems, such as batteries.

The Energy Storage Systems Program at Sandia National Laboratories would like your assistance in determining if a need for such a project exists, and, if so, what direction the project should take. Please complete the following survey and return it to Paul Butler. The staff of Energy Storage Systems Program appreciate your input and encourage comments and discussion on all of the survey questions. Use additional pages if necessary.

#### ***RGS Project Survey Questions***

- 1. What are your recommendations for the structure and implementation of the RGS Project?**

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- 2. Another group made suggestions that included a set of questions to be resolved. Please answer the following questions and provide supporting comments.**

*Should the project be market driven?*

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**Appendix F—Energy Storage Industry Survey**

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*Should DOE fund further R&D in batteries and advanced storage technologies now even if this means postponing systems research?*

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*How will DOE ensure that the proposed project does not interfere with current industry initiatives?*

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*Should the proposed project be combined with current initiatives of the Federal Government and national laboratories?*

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*Should work focus on factory-integrated, turnkey systems or on modular components that are integrated by the system suppliers?*

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3. The previous group made the following four key points. Please indicate your level of agreement with each point and provide supporting comments.

1—Strongly Disagree

2—Disagree

3—No Comment

4—Agree

5—Strongly Agree

*More information on energy storage devices/more emphasis on enhancing the utilization of these devices, and/or find a better device.*

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*Government should support either an integrated or a modular system, but the decision should be market driven.*

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*Use a contest format, to choose who will receive the bulk of the R&D money.  
The project should have a component focus, particularly emphasizing system-monitoring components.*

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## Appendix G—Acronyms and Abbreviations

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**AC:** alternating current

**APC:** Applied Power Corporation

**CEC:** California Energy Commission

**DC:** direct current

**DOD:** Department of Defense

**DOE:** Department of Energy

**EPRI:** Electric Power Research Institute

**ESA:** Energy Storage Association

**ESSP:** Energy Storage Systems Program

**MSDS:** material safety data sheet

**NEC:** National Electric Code

**NREL:** National Renewable Energy Laboratory

**PV:** photovoltaic(s)

**PVMat:** “PV Manufacturing Technology” (NREL-sponsored PV program)

**PVBonus:** “Building Opportunities in the US for Photovoltaics” (DOE/Golden Field Office-sponsored PV program)

**R&D:** research and development

**RFP:** request for proposal

**RGS:** renewable generation and storage

**SEIA:** Solar Energy Industries Association

**SMES:** superconducting magnetic energy storage

**SNL:** Sandia National Laboratories

**SOW:** statement of work

## **Appendix G—Acronyms and Abbreviations**

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**UPG:** Utility Power Group

**UPS:** uninterruptible power supply

**VRLA:** valve-regulated lead-acid

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## Appendix H—References

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1. Paul C. Butler. *Energy Storage Systems Program Report for FY96*. SAND97-1136, April 1997.
2. *Energy Storage Systems Program Multi-Year Program Plan FY1998-2002*. DRAFT.
3. Dr. Christine Platt, Paula Taylor, Laura Charles, and Paul C. Butler. *Report on the Energy Storage Systems Program Executive Meetings Project*. SAND97-2700, November 1997.